

REMARKS

In the specification, one paragraph has been amended to correct a minor typographical error.

In the amended drawings, replacement sheets have been provided to correct gray-scale shading, i.e., to provide the proper formatting required under 37 CFR 1.84. No new matter has been added.

Claim 8 has been canceled and its subject matter incorporated into claim 1. Further support for this amendment can be found in the specification on at least at page 9, lines 15 – 31.

Claims 17 and 18 have been added. Support for the additional claims can be found on at least page 2, lines 18 – 23 and page 8, lines 5 – 8.

Claims 1 – 7 and 9 – 18 are present in the subject application.

In the Office Action dated January 13, 2005, the Examiner has objected to the drawings, has rejected claims 1 – 7 and 12 – 14 under 35 U.S.C. §102(b), and has rejected claims 1, 2, and 7 – 11, 15, and 16 under 35 U.S.C. §103(a). Favorable reconsideration of the subject application is respectfully requested in view of the following remarks.

Initially, the Examiner has objected to the drawings under 37 CFR 1.83(a) on the basis that the drawings fail to show the resonator structures recited in claims 13 – 15. This objection is respectfully traversed. Conventional features disclosed in the description and claims, where their detailed illustration is not essential for a proper understanding of the invention, may be illustrated in the drawing in the form of a graphical drawing symbol or a labeled representation

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(e.g., a labeled rectangular box). *See* 37 CFR 1.83(a). The resonator structures are represented, for example, by functional blocks 4 and 5 in Fig. 1. The specification, moreover, clarifies on page 7, line 10 through page 8, line 4 that the claimed structure is an implementation of elements 4, 5. Accordingly, the Examiner is respectfully requested to reconsider and withdraw this objection.

Claims 1, 2, and 7 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,295,861 to Tom et al. The Examiner takes the position that the Tom et al. patent discloses all the features recited within these claims. This rejection is respectfully traversed since the Tom et al. patent does not disclose, teach, or suggest the features recited in amended independent claim 1 of a micromachined semiconductor sensor including a resonating structure having a resonant frequency dependent upon an *acoustic characteristic* of a gas. As an initial matter, it is the Examiner's position that the phrase "physical characteristic of a gas" includes the ability of the sensor material to adsorb components of a gas. Adsorption, however, is a chemical characteristic, not a physical characteristic. Adsorption is the adhesion of a thin layer of molecules to the surfaces of solids or liquids. Consequently, sensors identifying pollutants via adsorption are chemical sensors, and make use of a chemical characteristic of the sensor material (or of material coating the sensor), namely, the material's affinity for the pollutant components within the gas, to identify pollutants. The specification, moreover, clearly distinguishes a physical characteristic of a gas from a chemical characteristic. For example, on page 2, lines 12 – 24, the specification explains that chemical sensors (such as catalytic sensors) often result in

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chemical intoxication of the sensor, caused by the molecular interaction of the sensor with the gas. Physical sensors, in contrast, work passively, with little or no interaction with the gas on a molecular level. As such, the sensors of the Tom et al. patent (as well as the sensors of the Bowers et al. patent, discussed infra) do not have a resonant frequency based upon the physical characteristic of the gas filling the cavity.

Additionally, the adsorption sensors of the Tom et al. and the Bowers et al. patents have a resonant frequency based upon the sensor material and not the gas surrounding the sensor (and within the cavity). The change in resonant frequency of the Tom et al. and the Bowers et al. patents is caused by the weight differential resulting from a gas component being adsorbed by the sensor. *See* Tom et al. at col. 5, lines 24 – 37 and Bowers et al. at col. 3, lines 21 – 26. In contrast, the resonant change of the instant invention is not caused by the weight differential of the sensor, but by the physical composition of the gas surrounding the sensor as determined by acoustic principles. The gas component need not be absorbed to cause a change in resonant frequency.

Nonetheless, to further clarify the issue, the claims have been amended to specify that the physical characteristic upon which the resonating frequency is based is an acoustic characteristic. The Tom et al. patent discloses a device that detects the presence of a gas species by means of a differential quartz microbalance (QMB) arrangement. The gas species is detected as a result of a change in the resonant frequency of a piezoelectric device coated with a sensor material having

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an adsorptive affinity for the gas species. As noted above, this change is caused by a change in the mass of the QMB resulting from the coating adsorbing the gas species.

In contrast, the sensor element of the instant invention includes a resonator having a resonant frequency that varies with changes in the acoustic properties of the gas in the cavity, i.e., in the atmosphere surrounding the sensor. As discussed on original page 7, line 10 through page 8, line 18, the sensor element of the instant invention includes a resonator having a resonant frequency that varies with changes in the acoustic properties of the gas in the cavity. Specifically, by relating a resonant frequency to an acoustic property (such as the velocity of sound through the atmosphere surrounding the resonator, or the density of the gas surrounding the resonator), passive detection is achieved with little or no interaction with the gas on a molecular level. For example, as discussed on page 7, lines 10 - 19 of the specification, a Kundt resonator uses a standing wave pattern to determine the composition of the gas within a cavity. The presence of a pollutant shifts the resonant frequency of the gas, enabling the detection of a pollutant within the cavity. Consequently, the pollutant does not react with the resonating structure.

The sensor of the Tom et al. patent, in contrast, includes a catalytic sensor that measures the change in resonance resulting from a chemical reaction, i.e., an interaction with the gas on a molecular level. As discussed in the specification on page 2, lines 12 - 23, this type of catalytic sensor is disadvantageous because species within the gas may irreversibly bind to the sensor material and thereby reduce the sensitivity of the sensor. The sensor of the instant invention

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overcomes this disadvantage by using *acoustic* detection principles rather than *chemical* detection principles.

Since the Tom et al. patent does not disclose, teach, or suggest the features recited within independent claim 1 as discussed above, this claim is considered to be in condition for allowance. Claims 2, 7, and new claims 17 & 18 depend, either directly or indirectly, from independent claim 1 and, therefore, include all the limitations of their parent claim. Claim 17 clarifies that the property measured is that of the gas surrounding the sensor (and not, e.g., of the material coated on the sensor). Claim 18 further clarifies that no molecular interaction between the gas and the sensor takes place. These dependent claims are considered to be in condition for allowance for substantially the same reasons discussed above in relation to their parent claim and for further limitations recited in the claims.

Claims 1 – 5 and 7 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 2,952,153 (Robinson). The Examiner takes the position that the Robinson patent discloses all the features recited within these claims. This rejection is respectfully traversed since the Robinson patent does not disclose, teach, or suggest the features recited in independent claim 1 of a *micromachined semiconductor* sensor including a resonating structure having a resonant frequency dependent upon an acoustic characteristic of a gas.

Robinson discloses a device comprising a pair of acoustic resonators adapted for use with a gas chromatograph. Each resonator has a resonant frequency output dependent upon the composition of the gas present in each resonator. Robinson does not teach a micromachined

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semiconductor sensor structure. A micromachined structure provides a MEMS compatible device suitable for use with applications requiring small, low cost semiconductor sensors for flexible, distributed, air quality detection systems. As disclosed in the specification on page 9, lines 15 – 31, MEMS processes are based on single crystalline, silicon wafers, and have the capability and the capacity to produce very large numbers of sensor elements at very low cost. In contrast, the Robinson patent neither discloses a micromachined structure, nor discusses the technical challenges associated with providing such a MEMS-compatible, gas content microsensor.

Claims 2 – 5, 7, and new claims 17 & 18 depend, either directly or indirectly, from independent claim 1 and, therefore, include all the limitations of their parent claim. These dependent claims are considered to be in condition for allowance for substantially the same reasons discussed above in relation to their parent claim and for further limitations recited in the claims.

Claims 1 – 6 and 12 – 14 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,255,964 (Morison). The Examiner takes the position that the Morison patent discloses all the features recited within these claims. This rejection is respectfully traversed since the Morison patent does not disclose, teach, or suggest the features recited in amended independent claim 1 of a *micromachined semiconductor* sensor including a resonating structure having a resonant frequency dependent upon an acoustic characteristic of a gas.

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Morison discloses a fluid monitor for determining the percent composition of a fluid mixture of unknown composition when compared to a reference fluid mixture of known composition. The monitor includes a reference acoustic chamber and a sample acoustic chamber, each containing an acoustic transmitting transducer and an acoustic receiving transducer. The transmitting transducer generates an acoustic signal, which travels across the chamber and through the reference fluid to the receiving transducer. The resonant frequencies of the fluid in the reference chamber and the fluid in the sample chamber are compared, and the percent composition of the sample fluid mixture is calculated. Morison does not teach a micromachined semiconductor sensor structure. As noted above, a micromachined structure provides a MEMS compatible device suitable for use with applications requiring small, low cost semiconductor sensors for flexible, distributed, air quality detection systems. MEMS processes are based on single crystalline, silicon wafers, and have the capability and capacity to produce very large numbers of sensor elements at very low cost. *See* the specification on page 9, lines 15 – 31. In contrast, the Morison patent neither discloses a micromachined structure, nor discusses the technical challenges associated with providing such a MEMS-compatible, gas content microsensor.

Claims 2 – 6, 12 – 14, and new claims 17 & 18 depend, either directly or indirectly, from independent claim 1 and, therefore, include all the limitations of their parent claim. These dependent claims are considered to be in condition for allowance for substantially the same

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reasons discussed above in relation to their parent claim and for further limitations recited in the claims.

Claims 1, 2, and 7 – 11 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,321,588 (Bowers et al.) in view of U.S. Patent No. 6,684,683 (Potyrailo et al.). The Examiner takes the position that modifying the Bowers device with multiple cavities and cantilevers to form the array (both as argued to be taught by the Potyrailo et al. patent), as well as to use cantilevers of a micromachined silicon structure (as argued to be within the knowledge of one skilled in the art) would have been obvious. Initially, claim 8 has been canceled and its subject matter incorporated into claim 1. With regard to the remaining claims, the rejection is respectfully traversed since neither the Bowers et al. patent nor the Potyrailo et al. patent discloses, teaches, or suggests the features recited in amended independent claim 1 of a micromachined semiconductor sensor including a resonating structure having a resonant frequency dependent upon an *acoustic characteristic* of a gas.

The Bowers et al. patent discloses a device for detecting chemical substances using a plurality of surface acoustic wave (SAW) sensors arranged in an array. The sensors include piezoelectric crystals having resonant frequencies that vary as a function of the mass of the contaminant adsorbed onto the crystal surface. *See* col. 3, lines 20 – 22. As explained above (with regard to the Tom et al. patent), an adsorption sensor chemically reacts with the gas, interacting with the gas at a molecular level. It is the gas component bound to the sensor that alters the resonating frequency of the sensor. Consequently, components within the gas bind to

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the crystal, reducing the sensitivity of the sensor. In contrast, the sensor of the instant invention uses physical (not chemical) detection principles, wherein the resonating structure has a resonant frequency dependent upon an *acoustic* characteristic of a gas in the atmosphere within the sensor cavity (and not upon a component chemically bound to the sensor). *See* the specification at page 7, line 10 through page 8, line 18. Specifically, by relating a resonant frequency to a physical property such as the velocity of sound through the atmosphere surrounding the resonator, or to the density of the gas surrounding the atmosphere, passive detection is achieved with little or no interaction with the gas on a molecular level. As such, the Bowers patent does not have a resonant frequency dependent upon an acoustic characteristic of a gas.

The Potyrailo et al. patent does not compensate for the deficiencies of the Bowers et al. patent and similarly, does not disclose, teach, or suggest these features. The Potyrailo et al. patent shows an arrangement in which the output parameters of acoustic wave devices vary as a function of analyte concentration in, and thus the mass of, a coating deposited on a surface of those devices. *See* col. 3, lines 1 – 9. Such as resonator structure measures pollutant components using chemical principles--the sensor coating chemically reacts with components of the gas by binding with the components. It is this binding that alters the resonant frequency of the sensor. In contrast, the instant invention the change in resonator frequency is based upon an acoustic characteristic of the gas surrounding the sensor.

Since the Bowers et al. and the Potyrailo et al. patents do not disclose, teach, or suggest, either alone or in combination, the features recited within claim 1, as discussed above, these

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claims are considered to be in condition for allowance. Claims 2, 7, 9 – 11, and new claims 17 & 18 depend, either directly or indirectly, from independent claim 1 and, therefore, include all the limitations of their parent claim. These dependent claims are considered to be in condition for allowance for substantially the same reasons discussed above in relation to their parent claim and for further limitations recited in the claims.

Claim 15 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 4,255,964 (Morison) in view of GB Patent No. 2,288,660 (Fischer). It is the Examiner's position that replacing the resonator of the Morison sensor with the Helmholtz resonator taught by Fischer would be obvious. This rejection is respectfully traversed. Initially, claim 15 depends from independent claim 1 and, therefore, includes all the limitations of its parent claim. This dependent claim is considered to be in condition for allowance for substantially the same reasons discussed above in relation to its parent claim and for further limitations recited in the claim. As discussed in greater detail above, the Morison patent does not disclose, teach, or suggest the features recited in independent claim 1 of a *micromachined semiconductor* sensor including a resonating structure having a resonant frequency dependent upon an acoustic characteristic of a gas.

In addition, the Fischer patent does not compensate for the deficiencies of the Morison patent and similarly, does not disclose, teach, or suggest these features. The Fischer patent is directed to a thermoacoustic vibration dampener and, as such, does not disclose, teach or suggest a micromachined semiconductor as currently recited in the claims.

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Claim 16 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 4,255,964 (Morison) in view of the article entitled "New CO₂ Sensor with Fast Resolution and Fast Response" (Granstedt). It is the Examiner's position that replacing the resonator of the Morison sensor with the microacoustic resonator taught by Granstedt would be obvious. This rejection is respectfully traversed. Initially, claim 16 depends from independent claim 1 and, therefore, includes all the limitations of its parent claim. This dependent claim is considered to be in condition for allowance for substantially the same reasons discussed above in relation to its parent claim and for further limitations recited in the claim. As discussed above, the Morison patent does not disclose, teach, or suggest the features recited in independent claim 1 of a *micromachined semiconductor* sensor including a resonating structure having a resonant frequency dependent upon an acoustic characteristic of a gas. The Granstedt article, moreover, does not compensate for the deficiencies of the Morison patent and similarly, does not disclose, teach, or suggest these features. The Granstedt article discloses a single element sensor for measuring CO₂ in biomedical applications. In contrast, the sensor of the instant invention includes a housing with multiple cavities and a sensors operable to measure resonant frequencies dependent upon an acoustic characteristic of the gas, comparing output of the cavities to monitor the content gas contained within the cavities.

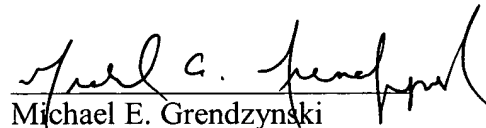
In addition to the foregoing, it would not be obvious to combine the Morison patent with the teachings of the Fischer patent or the Granstedt article to obtain the claimed invention. The Morison patent is concerned with determining the percent composition of fluid mixtures,

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whereas the Fischer patent is concerned with damping thermoacoustic vibrations in a combustion chamber. Thus, the Morison patent and the Fischer patent are concerned with diverging applications and there is no apparent reason to combine their teachings other than prohibited hindsight derived from Applicant's own disclosure. In addition, the Morison patent discloses the use of a transmitter/receiver *pair*, while the sensor of the Granstedt article uses a *single* element sensor to measure CO₂ in biomedical applications. Thus, one skilled in the art would not look to the Granstedt article to address the deficiencies of the Morison patent. Combination of the two systems would lead to unpredictable results.

In view of the foregoing, Applicants respectfully request the Examiner to find the application to be in condition for allowance with claims 1 – 7 and 9 – 16. However, if for any reason the Examiner feels that the application is not now in condition for allowance, he is respectfully requested to call the undersigned attorney to discuss any unresolved issues and to expedite the disposition of the application.

Respectfully submitted,


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APPENDIX

Amendments to the Drawings:

The attached sheets of drawings include FIGS. 1 – 3. These sheets replace the sheets previously submitted with the Amendment dated December 1, 2004.